PROTOTYPE OF THE GIS TOOL

D.T1.2.1

Version *1*

June 2018

WP	W T1: Identification of potential locations of the Natural Small Water Retention measures

Activity	Act. 1.2. Prototype of the GIS tool and training
Activity leader	WULS
Number and name of the deliverable/output	D.T1.2.1 Prototype of the Gis Tool
Participating partners	only WULS
Type of the deliverable/output (analysis, report, guideline, workshop, brochure, etc.)	Software
Purpose of the deliverable/output	to support partners in preparation of the concept and action plan. Additionally to create a valorisation map for the Decision Support System and Guidelines to improve water balance and nutrient mitigation by applying a system of N(S)WRM
Connection with other deliverables	D.T1.3.1, D.T2.3.1, D.T2.3.2, D.T3.4.1-4, D.T3.5.3
Start date	**Sep-17**
End date	**Mar-18**

Content

1 Introduction

In accordance with the guidelines included in the first version of the valorisation method described in the deliverable D.T1.1.1, an IT tool was developed with a draft name "Prototype of GIS Tools". The purpose of the tool is to automate the valorisation process. Initially this tool will be tested by partners in six pilot catchments. Testing the tool enables to check the valorisation method in different scale, human pressure and environmental condition. Finally, it is planned to supplement the valorisation method and update the Prototype software.

2 Choice of technology

The preliminary assignment included a review of existing IT tools and open source technologies that are rich in statistical and spatial (GIS) computing libraries. Particularly noteworthy was the software produced within the framework of the FREEWAT project which aims to promote water resource management by simplifying the application of the Water Framework Directive and other EU water related Directives. This software is written in Python and embedded with the QGIS program, which requires the user to carry out an installation and to be familiar with this software. The ToolKit Nutrient application developed by a team of scientists (Geoff Philips & Gabor Varbiro) on behalf of JRC European Commission and available under the link http://phytoplanktonfg.okologia.mta.hu:3838/ Tkit_nutrient / proven to be the most interesting tool. This application was written in R language and embedded in the Shiny Server environment. The advantage of this application was a user friendly interface supported by the website without a need of installation by the user. Finally, it was decided to embed the GIS Tool application on the virtual machine Docker engine, on which Debian OS and Rocker / Shiny images will be installed. Based on these findings and the scope given in the valorisation method, a competition was announced and the contractor was selected to prepare the application.

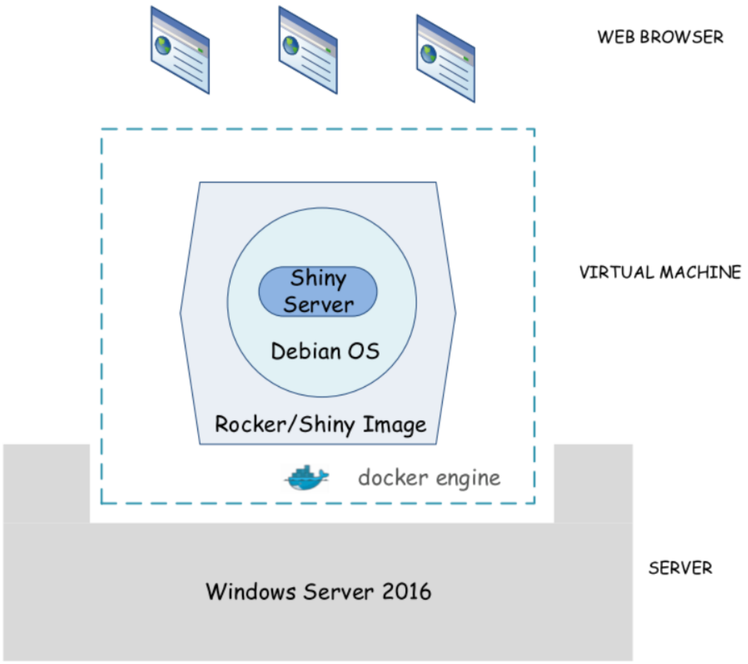

Fig. 1 Structure of the GIS Tools application

3 Graphic user interface project

The basis for the development of the GUI project was the computational algorithm proposed in the valorisation method (Fig. 2). On its basis, the contractor developed a project in the form of a matrix on which he applied particular types of objects (see Fig. 3-5). It consists of a series of tabs, which in an intuitive way enable the user to:

- go through the process of defining goals and spatial units,
- select the indicators and input the data,
- review and remove correlated indicators,
- define the classification and aggregation method,
- view and download the results of the valorisation.

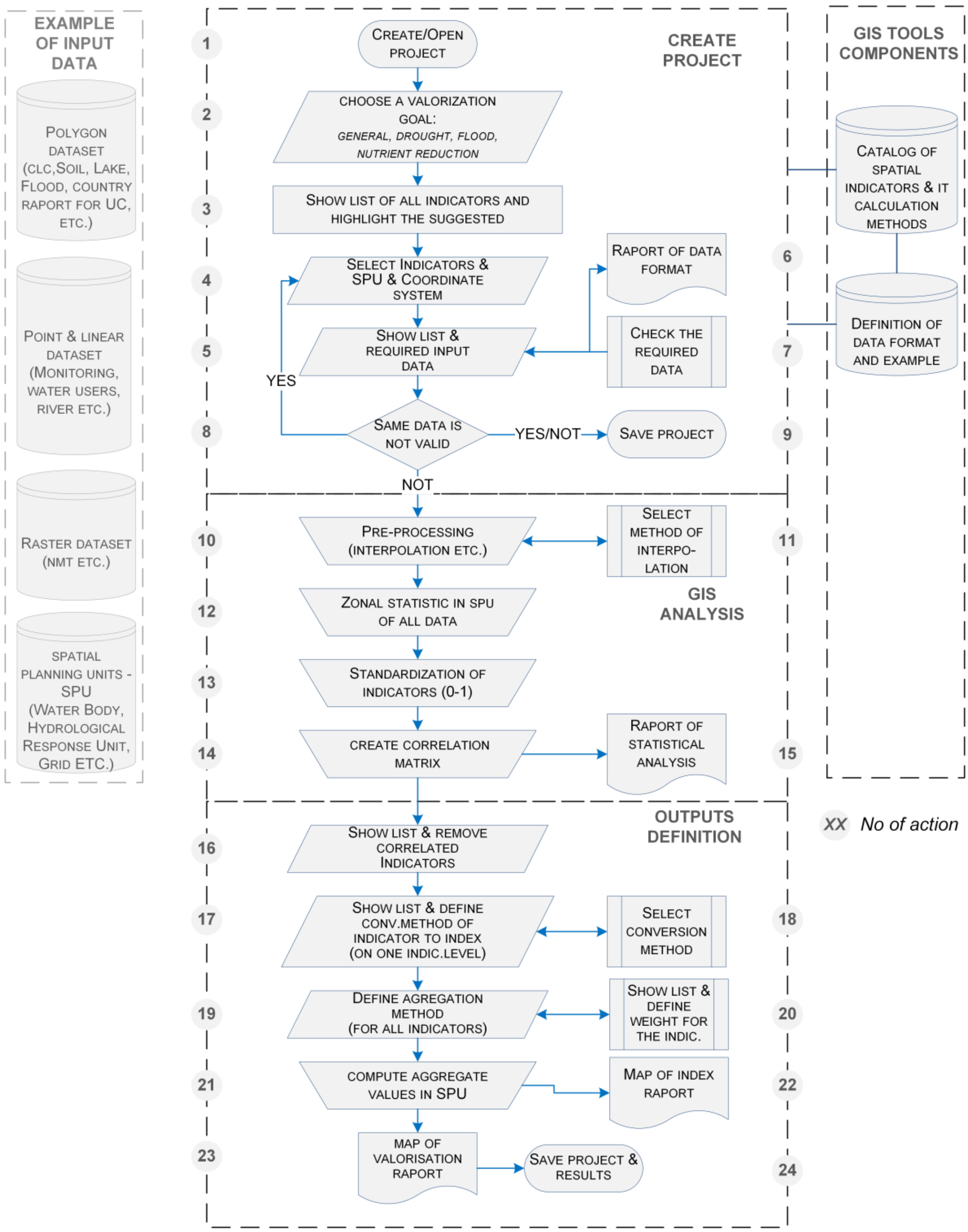

Fig. 2 Algorithm of the GIS tools for valorization of water retention needs (source D.T1.1.1)

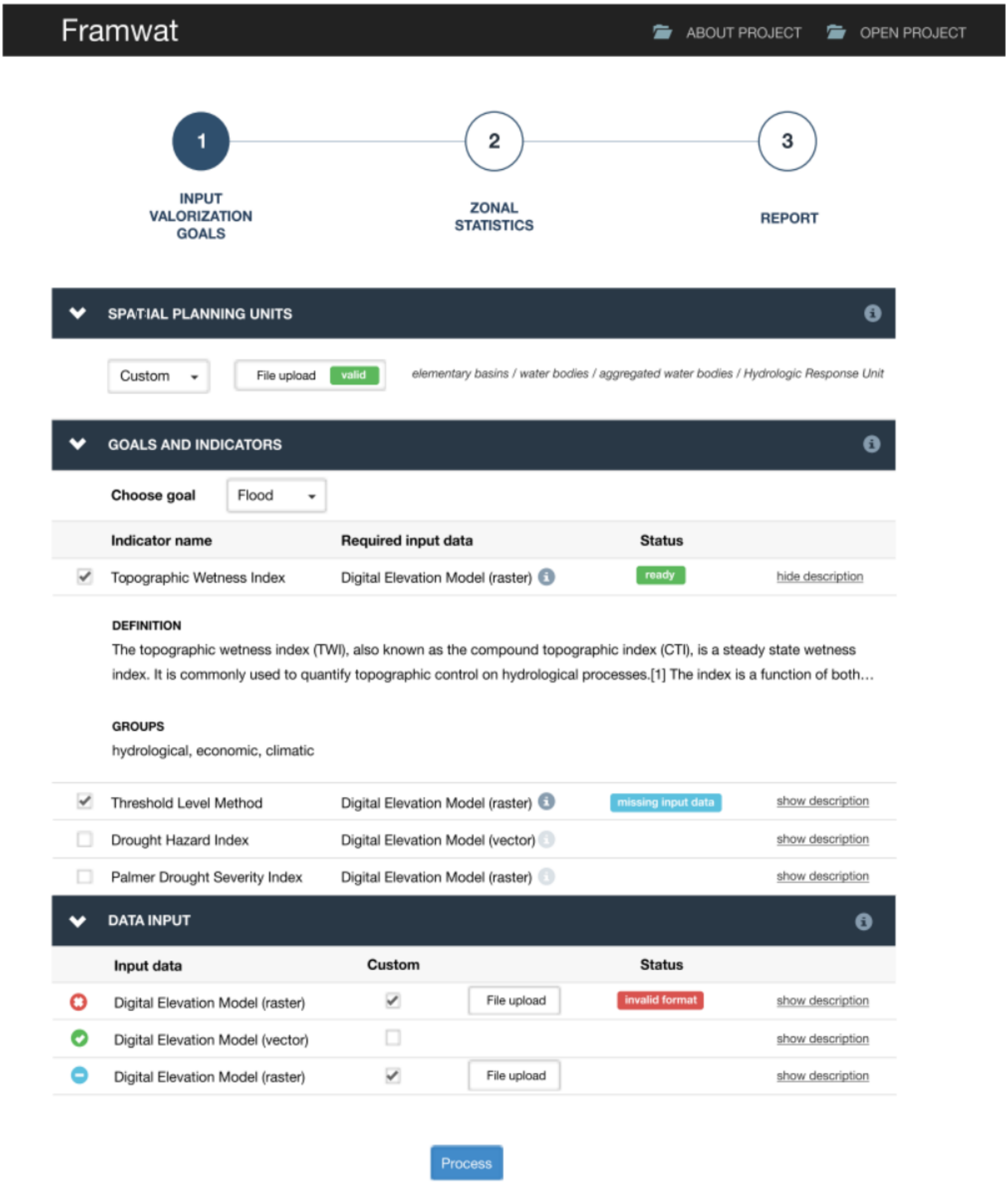

Fig. 3 The design of the first part of the matrix titled Input valorization goals

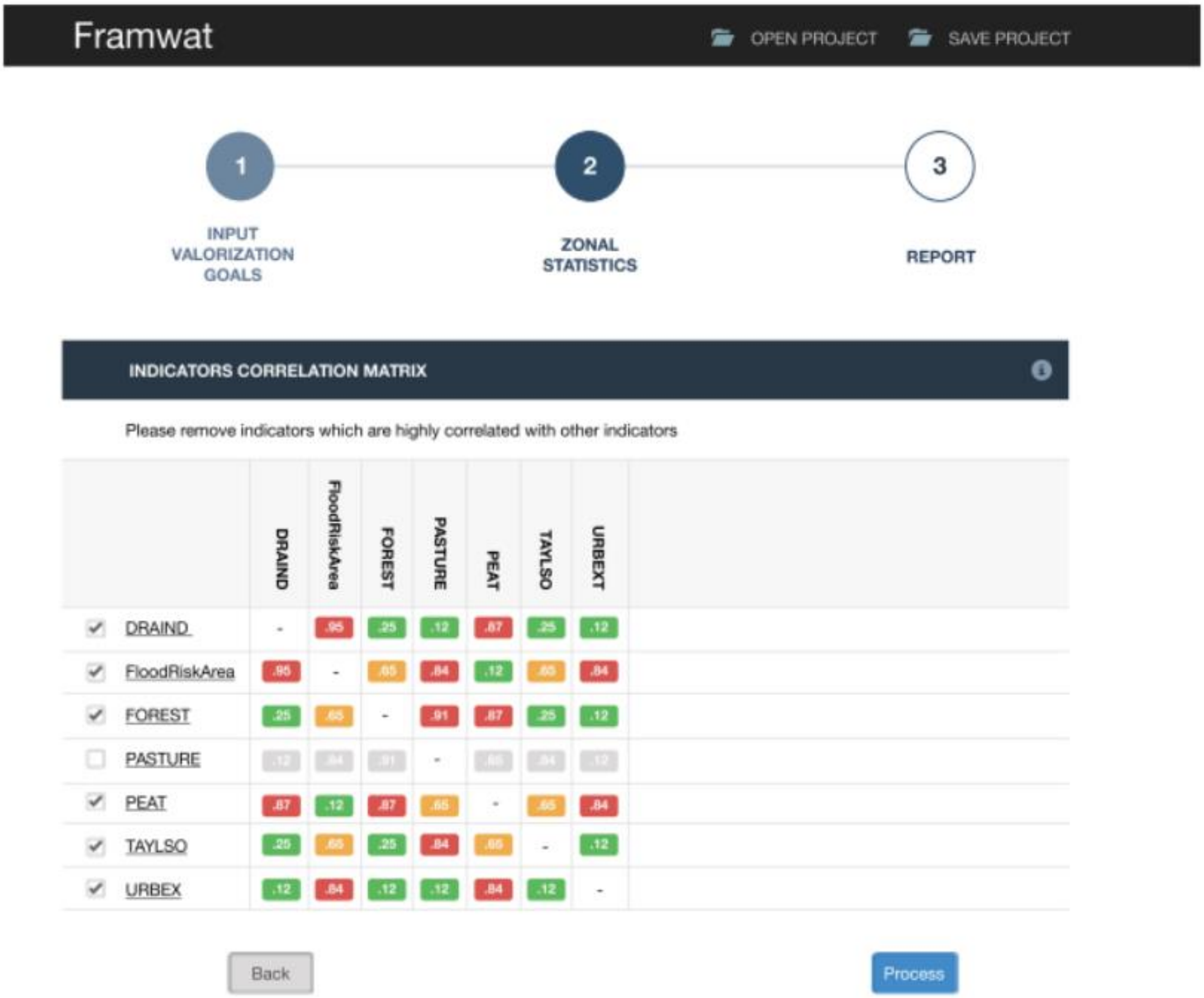

Fig. 4 The design of the second part of the matrix titled Zonal Statistics

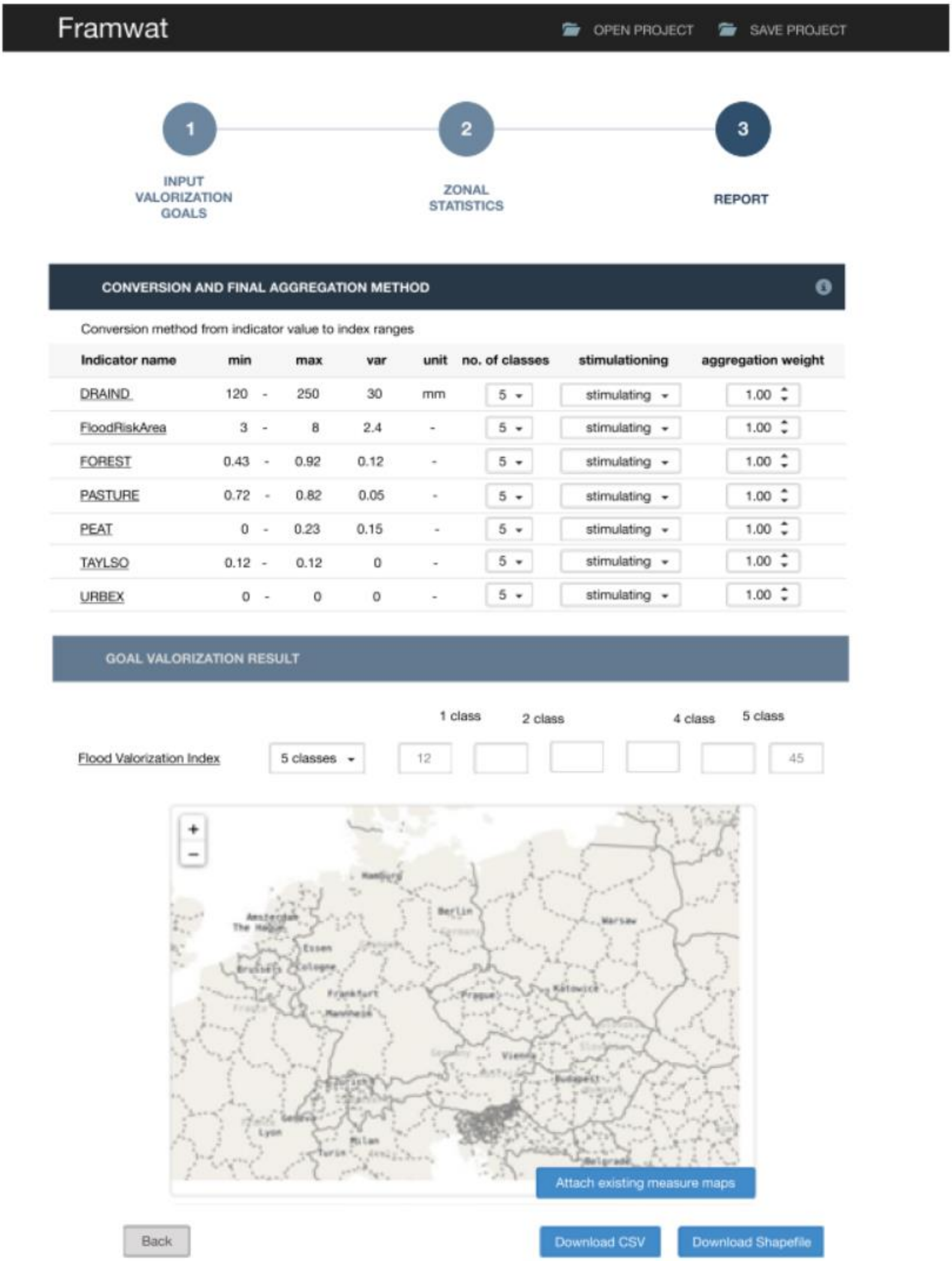

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Fig. 5 The design of the last part of the matrix titled Report

4 Conversion of the valorisation methodology into the apllication structure

Due to the fact that not all elements of the valorisation methodology were developed in the form of computational algorithms, its transcription required refinement and reformatting. Therefore, WULS employees together with external experts and the contractor of the application converted the methodological assumptions to the needs of the application. The scope of work included clarification of the valorisation method in the next field:
- choosing a list of indicators,
- describing the indicators in the form of formulas and calculation algorithms,
- adding the following features to the indicators: Name, Short Name, Description, Unit, Relation value to water retention needs and possibility of implementation,
- developing a list of input data and adding to them the following features: Name, Short Name, Unit, Description, Attributes,
- developing relationships between indicators and goals,
- developing relationships between indicators and input data.

The choice of indicators was based on the division of 47 indicators into groups with matching characteristics (ie Climatic, Hydrological, Geological, Topographic) and analysis of each of them in terms of relevancy, possibility of calculation with the use of generally available data and the overlapping indicators were removed. In the end, 34 indicators were selected, and a few new hydrological and water quality indicators were introduced. The final list is presented in Tab. 1. Then additional characteristics were added to the indicators and they were described in a way that enabled the development of a calculation function in the R program or a spreadsheet. On the basis of those descriptions, a data preparation instruction that is available from the GIS Tools application level, was created. In the next step, a list of input data and attributes was developed and a relationship between indicators and Input data was created. The results were consulted with project partners during the meeting in Bratislava and the conclusions were passed on to the contractor. A summary is presented in Tab. 2 and Table 3.

Tab. 1 Indicators list

Aim of assessment/ actions	IndicatorName	IndicatorShortName	Unit	Relation value to water retention needs and possibility: stimulant, destimulant
Drought	Climatic Water Balance	cwb	mm	destimulator
	Monthly Climatic Water Balance Variability- average intra annual variability for growing season (cwbMaxMth-cwbMinMth)/cwbAvgMth	cwb_Var_a	-	stimulator
	Growing Season Climatic Water Balance Variability - variability for the multiannual period cwbMin/cwb	cwb_Var_m	-	destimulator

Aim of assessment/ actions	IndicatorName	IndicatorShortName	Unit	Relation value to water retention needs and possibility: stimulant, destimulant
	Monthly Precipitation Variability - average intra annual variability for growing season - (pMaxMth - pMinMth)/pAvgMth	Pre_Var_a	-	stimulator
	Growing Season Precipitation Variability for the multiannual period [pMin]/[P]	Pre_Var_m	-	destimulator
	Frequency of precipitation lower than 50% of the multiannual average (in the growing season)	PrecFreqLow50	-	stimulator
	Maximum soil water retention	swr	mm	destimulator
	Groundwater Renewable Resources Module	grr	mm	destimulator
	Surface Runoff Index	sri	-	stimulator
	Base Flow Index	bfi	-	destimulator
	Mean low flow to mean high flow ratio	FlowMinMaxRatio	-	destimulator
	Mean low flow to mean flow ratio	FlowMinAvgRatio	-	destimulator
	Low mean flow to hight mean flow ratio	FlowVarRatio_m	-	destimulator
	Water yield (specific runoff) for low flow in the multiannual period	WaterYieldMinFlow	mm	destimulator
	Water yield (specific runoff) for mean flow n the multiannual period	WaterYieldAvgFlow	mm	destimulator
Flood/Drought	Surface Runoff Index	sri	-	stimulator
	Base Flow Index	bfi	-	destimulator
	Mean low flow to mean high flow ratio	FlowMinMaxRatio	-	destimulator
Flood	Ratio of high low flow to mean flow in the multiannual period	FlowMaxAvgRatio	-	stimulator
	Taylor-Schwartz measure of mainstream slope	TaySLO	-	stimulator
	Flood hazard zone area ratio	FloodRiskAreaRatio	%	stimulator
	Non forested area with a slope above 5% to SPU area ratio	NonForestedRatio	-	stimulator
	Lake catchment area to SPU area ratio	LakeCatchRatio	%	destimulator
Flood/ Drought (the land use and topography	Drainage Density	DrainageD	km/mk2	stimulator
	Topographic Wetness Index	twi	-	destimulator
	Forested area to SPU area ratio	ForestRatio	%	destimulator

Aim of assessment/ actions	IndicatorName	IndicatorShortName	Unit	Relation value to water retention needs and possibility: stimulant, destimulant
group)	Lakes and reservoirs area to SPU area ratio	LakeRatio	%	destimulator
	Wetland area to SPU area ratio	WetladRatio	%	destimulator
	Orchards & vegetable farming area to SPU area ratio	OrchVegRatio	%	stimulator
	Urban area to SPU area ratio	UrbanRatio	%	stimulator
	Arable area in SPU area ratio	ArableRatio	%	stimulator
	Reclaimed meadows and pastures area to SPU area ratio	ReclaimedRatio	%	stimulator
Quality (High values indicate the need to develop NSWRM)	Non forested areas with a slope above 5% to SPU area ratio	NonForestedRatio	%	stimulator
	Arable lands in 20-meters buffer around surface waters area to SPU area ratio	EcoAraBuf20mRatio	-	stimulator
	Semi-natural land cover types area to SPU area ratio	EcoAreaRatio	%	destimulator
	Number of semi-natural land cover patches to total number of land cover patches in SPU	EcoNumRatio	%	destimulator
	Combination of number of semi-natural land cover patches and their area	EcoCombined	-	destimulator - look-up table
	Bad morphological elements length to total length of river in SPU	EcoBadRHS	%	stimulator

Tab. 2 Input data list

Data short name	Data full name	Input data format	Attributes name	Attributes full name	Unit
Arable	Arable land layer (e.g. in CLC codes: 211,212,213)	polygon	Area		m2
BadRHS	River Hydromorphology Status (assessed and not assessed river sections (e.g. by River Habitat Survey)) [-]	polyline	Length		m
bfi	BaseFlow Index; bfi= 1/NYears * 1/12 * sum(swLQij / swMQij), i=1,NYears, j=1,12 months, swLQij-the lowest of daily flows within a month, swMQij-mean monthly flow; [-]	polygon	bfi	Base Flow Index-groundwater contribution to river flow	-
cwb	Avarage Climatic Water Balance during the growing season [mm]	raster	Value	Avarage Climatic Water Balance during the growing season [mm]	mm
cwb_Var_a	Monthly Climatic Water Balance Variability- average intra annual variability for growing season (cwbMaxMth-cwbMinMth)/cwbAvgMth [mm]	raster	Value	Monthly Climatic Water Balance Variability- average intra annual variability for growing season (cwbMaxMth-cwbMinMth)/cwbAvgMth	mm
cwbMin	Minimum (first mean for each year then min) Climatic Water Balance during the growing season cwbMinAnn[mm]	raster	Value	Minimum (first mean for each year then min) Climatic Water Balance during the growing season cwbMinAnn[mm]	mm
DEM	Digital Elevation Model [m a.s.l.]	raster	Value		m a.s.l.
Ditches	Ditches	polyline	Length		m

Data short name	Data full name	Input data format	Attributes name	Attributes full name	Unit
FloodExtent	Flood extent (e.g. probability 1% (100 years))	polygon	Area		m2
Forest	Forest layer (e.g. in CLC codes:311,312,313)	polygon	Area		m2
grr	Groundwater Renewable Resources Module [mm]	raster	Value	groundwater renewable resources module	mm
gwCONTAMsw	Map of groundwater contamination hazard from the land/terrain surface	polygon	Problems	Main groundwater problems from the land surface hazard	-
HydTechCon	Existing Natural Small Water Retention Measures	polygon	Type	Type of Natural Small Water Retention Measures	
Lake	Lake	polygon	Area		m2
LakeCatch	Lake Catchment	polygon	Area		m2
LandUse	Landuse layer (e.g. CLC)	polygon	Area		m2
MeadPastur	Meadows and pastures (CLC code: 231)	polygon	Area		m2
NonForest	NonForest layer (e.g. in CLC not codes:311,312,313)	polygon	Area		m2
nvz	Nitrate Vulnerable Zones Maps	polygon	Type	Type of Nitrate Vulnerable Zones	
Orchard	Orchard layer (e.g. in CLC code:222)	polygon	Area		m2
PhysChemAs	Physicochemical quality assessment of surface waters	polygon	Problems	A description of the results of the evaluation overruns and physico-chemical determinations	-
PrecAnn	Precipitation Station data with multiannual statistics for annual sum [mm]	point	pAvgAnn	Mean annual sum of precipitation	mm
PrecWeg	Precipitation Station data with multiannual statistics for growing seasonal sum [mm]	point	preVar_a	Monthly Precipitation Variability - average intra annual variability for growing season - (pMaxMth - pMinMth)/pAvgMth	mm
			pAvgWeg	Multiannual average precipitation during the growing season (sum)	mm
			pMinWeg	Multiannual maximum precipitation during the growing season (sum)	mm
PrecWegF50	Frequency of precipitation lower than 50% of the multiannual average (in the growing season) [-]	point	pFreqLow50	Frequency of precipitation lower than 50% of the multiannual average (in the growing season)	-
ProtArea	Protected Areas Map	polygon	Type	Type of protected area	-
River	River network	polyline	Length		m
River500	River network divide on 500m segments	polyline	Length		m
SemiNatural	Semi-natural land (CLC code: 231,311,312,313,321,322,323,324,331,332,333,334,335,411,412,421,422,423)	polygon	Area		m2
SPU	Spatial Planning Unit (Subasin, Water Body)	polygon	Area		m2
SubCatch	River subbasin (subcatchment)	polygon	Area		m2
swFlow	Surface water multiannual flow characteristics [mm]	polygon	swMHQ	Surface Water multiannual Mean Hight Flow [mm]	mm
	Surface water multiannual flow characteristics [mm]	polygon	swLMQ	Surface Water multiannual Low Mean Flow [mm]	mm
	Surface water multiannual flow characteristics [mm]	polygon	swHMQ	Surface Water multiannual High Mean Flow [mm]	mm

Data short name	Data full name	Input data format	Attributes name	Attributes full name	Unit
	Surface water multiannual flow characteristics [mm]	polygon	swMMQ	Surface Water multiannual Mean Mean Flow [mm]	mm
	Surface water multiannual flow characteristics [mm]	polygon	swMLQ	Surface Water multiannual Mean Low Flow [mm]	mm
swr	Soil Water Retention in 1m depth (maximum or available for plants 2-4.2 for pF) [mm]	raster	Value	Soil Water Retention in 1m depth (maximum or optionally 2-4.2 for pF)	mm
Urban	Urban layer (e.g. in CLC codes:111,112,121,122,123,124)	polygon	Area		m2
Wetland	Wetland layer (e.g. in CLC code:411,412,421,422,423)	polygon	Area		m2

Tab. 3 Relationship between indicator and input data

Indicator Short Name	Data Short Name	Indicator Short Name	Data Short Name
	Arable.Area		grr.Value
ArableRatio	SPU.Area	**grr**	SPU.Area
bfi	bfi.bfi		LakeCatch.Area
bfi	SPU.Area	**LakeCatchRatio**	SPU.Area
	cwb.Value		Lake.Area
cwb	SPU.Area	**LakeRatio**	SPU.Area
	cwb_Var_a.Value		DEM.Value
cwb_Var_a	SPU.Area		NonForest.Area
	cwb.Value	**NonForestedRatio**	SPU.Area
	cwbMin.Value		Orchard.Area
cwb_Var_m	SPU.Area	**OrchVegRatio**	SPU.Area
	River.Length		PrecWeg.preVar_a
DrainageD	SPU.Area	**Pre_Var_a**	SPU.Area
	River.Length		PrecWeg.pAvgWeg
	Ditches.Length		PrecWeg.pMinWeg
	Lake.Area	**Pre_Var_m**	SPU.Area
	Arable.Area		PrecWegF50.pFreqLow50
EcoAraBuf20mRatio	SPU.Area	**PrecFreqLow50**	SPU.Area
	SemiNatural.Area		MeadPastur.Area
EcoAreaRatio	SPU.Area		Ditches.Length
	BadRHS.Length	**ReclamedRatio**	SPU.Area
EcoBadRHS	SPU.Area		PrecAnn.pAvgAnn
	SemiNatural.Area		swFlow.swMMQ
	LandUse.Area	**sri**	SPU.Area
EcoCombined	SPU.Area		swr.Value
	SemiNatural.Area	**swr**	SPU.Area
	LandUse.Area		DEM.Value
EcoNumRatio	SPU.Area		River500.Length
FloodRiskAreaRatio	FloodExtent.Area	**TaySLO**	SubCatch.Area

Indicator Short Name	Data Short Name	Indicator Short Name	Data Short Name
	SPU.Area		SPU.Area
FlowMaxAvgRatio	swFlow.swMHQ	twi	DEM.Value
	swFlow.swMMQ		SPU.Area
	SPU.Area	UrbanRatio	Urban.Area
FlowMinAvgRatio	swFlow.swMLQ		SPU.Area
	swFlow.swMMQ	WaterYieldAvgFlow	swFlow.swMMQ
	SPU.Area		SPU.Area
FlowMinMaxRatio	swFlow.swMLQ	WaterYieldMinFlow	swFlow.swLMQ
	swFlow.swMHQ		SPU.Area
FlowVarRatio_m	swFlow.swLMQ	WetladRatio	Wetland.Area
	swFlow.swHMQ		SPU.Area
	SPU.Area		
ForestRatio	Forest.Area		
	SPU.Area		

5 Workflow

Due to the fact that the application is open source and in the future it can be developed further by other users, the whole project was created by the contractor on the GitLab portal at https://gitlab.com/framwat. As a result, the entire team consisting of six people had the opportunity to view the code, submit their functions and make comments in an orderly and safe way. Execution of the project on the GitLab platform (Fig. 6) enabled the partial automation of the testing process and the process of installing the remote application on the server. In addition, on the portal in the Wiki tab there are rules for building indicator functions and reports from meetings. The project partners were also given access to the project in read only mode. A large part of the team's work was focused on finding and preparing input data for testing applications. Two groups of global data were prepared as well as for the pilot catchment basin. Global data has been converted into common metric system and their coverage has been cut to the Central European region. The scope of collected data included: Community & Country Boundary, Hydrography from Ecrins, Land Use from CLC, DEM 25m from Copernicus, soil from SoilGids.org and HWSD, Hydrology from model HYPE3.0. The data for the Kamienna catchment was compiled in a scope covering all input data listed in Table 2. Based on this data, all functions were tested before being entered into the main program code. The tests took place at the beginning on the machine http://levis-framwat.sggw.pl, and in the last phase of the setting up process it was also installed on the Demo Server and is available at http://WaterRetention.sggww.pl (http: // RetencjaWod .sggw.pl). At the same time, work was carried out on the development of users input data and preparation of that data for the GIS tools, which is a very important element due to the fact that some of the indicators are based on flow, precipitation and evapotranspiration time series.

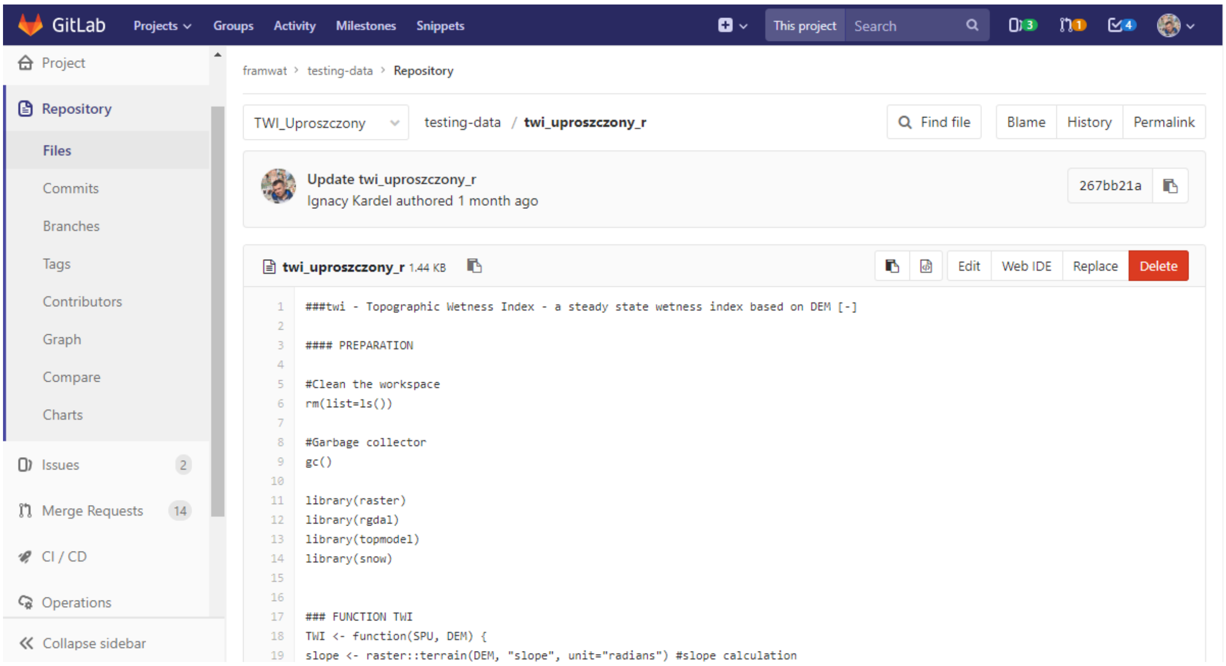

Fig. 6 Application design view on the portal Gitlab.

6 Description of the application

The application was created and is available under three http addresses: levis-framwat.sggw.pl, WaterRetention.sggw.pl, RetencjaWod.sggw.pl. It consists of the following elements:

- web application,
- methodology document,
- users input data preparation document,
- example of input data files and pre-processing tools,
- e-learning materials.

The application has the following functionality:

- supports vector data in * .shp format
- supports raster data in * .geotiff format
- supports 20 Geographic Coordinate Systems
- the ability to go back and update the list of indicators
- the ability to change the loaded data
- the user session expires only after a few days so that allows to stop working at any moment and returning to it the other day
- presentation of the correlation matrix
- presentation of the values of the indicators

- presentation of the result map in an interactive mode with the possibility of enlarging and changing the number of legend items

- the possibility of downloading the results of the valorisation,

- handy links to the methodology, instructions, sample data and course.

7 Conclusions

With the involvement of WULS employees and an external company, we managed to develop an application based on the latest open source technology, ie Server Shiny and one of the most popular programming languages - R. The application, in accordance with the assumptions, gives the user a great deal of freedom at working with the tool, which allows for the adjustment of the valorisation parameters to suit their needs. It is user-friendly even if a user does not have much knowledge of water management due to the fact that it has instructions, sample data and e-learning materials with a theoretical introductory lecture and other training materials. From the point of the project assumptions, it fulfils its role because it enables the analysis of the proposed methodology. As a prototype, it is not free of errors, which will be gradually removed in the process of testing it by partners.